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DOE/NASA CONTRACTOR REPORT

DOE/NASA CR-150612

SOLAR HEAT TRANSPORT FLUID A Quarterly Report

Prepared by

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P. O. Box 4026
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Under Contract NAS8-32255 with

National Aeronautics and Space Administration
George C. Marshall Space Flight Center, Alabama 35812

For the U. S. Department of Energy



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Quarterly Report, Nov. 1977 - Jan. 1978
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U.S. Department of Energy



Solar Energy

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16. ABSTRACT This report covers the progress made from November 1977 to January 1978 on the development and delivery of noncorrosive fluid subsystems. These subsystems are to be compatible with closed-loop solar heating or combined heating and hot water systems. They are also to be compatible with both metallic and non-metallic plumbing systems. At least 100 gallons of each type of fluid recommended by the contractor will be delivered under the contract. The performance testing of a number of fluids is described.					
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INTRODUCTION

The purpose of this project is to demonstrate a solar heat transport fluid which will provide corrosion and freeze protection for aluminum, copper and steel solar collectors using copper plumbing.

SUMMARY

Evaluation and testing of the solar heat transport fluids are continuing. The new appearance test procedure has been adopted and all samples have been retested. The appearance and pH data indicate that the systems with uninhibited glycols and glycerine are in an acid environment and have become darker in color. Therefore, corrosion in these systems is probably occurring. System No. 9 had a cracked weld which was repaired and testing is continuing with new deionized water test fluid. A Development Plan change and a three-month extension of contract have been submitted for NASA approval. A quarterly review with NASA personnel was held in Corpus Christi.

OPERATION OF THE SOLAR TEST STAND

Testing of the solar heat transport fluids is continuing on a 24-hour basis.

SOLAR HEAT TRANSPORT FLUIDS

Samples of the solar fluids are being taken monthly and analyzed for appearance, pH, and reserve alkalinity. The monthly wet chemistry report is enclosed.

To keep within the scope of the contract the appearance test was intended to be a visual test but since confusion can surface due to verbal interpretation, a visual comparative color method was developed based on the platinum-cobalt method. The two methods (PPG #73, "Determination of Color of Liquid Samples Referred to the Platinum-Cobalt Scale" and using the Hellige Aqua Tester), discussed in the November, 1977, combined monthly and quarterly report, were studied and the following modified method was derived.

The appearance is measured by visual comparison of the sample with platinum-cobalt standards in identical 4 oz. wide mouth sample bottles against a white background. Standards are 0, 50, 100, 250, and 500 units of color which is produced by 1 mg/l platinum in the form of the chloroplatinate iron. Two sets of vials containing samples of the color standard have been sent to NASA for their inspection.

All monthly samples have been retained and have been retested using the new appearance method. A composite sheet with all the appearance data is enclosed.

The general trend of the solar fluid appearance data shows that approximately 45% of the solar fluid on test for six months are lighter in color than after one month of testing. And approximately 39% of system's solar fluids did not change in color. Where 14% of the systems solar fluids darkened in color during the same period of time as shown in Table I.

TABLE I

SOLAR FLUID APPEARANCE APPROXIMATE CHANGE
(All Systems)

<u>Lighter</u>	<u>No Change</u>	<u>Darker</u>
47%	39%	14%

The above trend indicates that the steel tanks, heat exchanger shell and solar collectors inner surfaces had oxide films and possibly other debris on their walls. The solar systems were not surgically cleaned but simulate the condition of an average solar system. It's possible that the oxide films and debris were removed with time and precipitated out most likely in the storage tanks and heat exchanger shells.

The appearance change from July to December of inhibited glycols solar fluids excluding T-1 and T-2 fluids indicate that all systems improved in appearance. The systems with copper and aluminum solar collectors improved in appearance more than the steel collectors as shown in Table II below.

TABLE II

AVERAGE APPEARANCE CHANGE FOR INHIBITED SOLAR
FLUIDS DURING A SIX-MONTH PERIOD

<u>Copper</u>		<u>Aluminum</u>		<u>Steel</u>	
<u>July</u>	<u>Dec.</u>	<u>July</u>	<u>Dec.</u>	<u>July</u>	<u>Dec.</u>
92	25	67	33	125	108

The appearance change for the non-inhibited propylene glycol and mono-ethylene glycol solar fluids increased in color except for the copper collectors shown in Tables III and IV.

TABLE III

APPEARANCE CHANGE FOR PROPYLENE GLYCOL
WITHOUT INHIBITORS DURING A SIX-MONTH PERIOD

<u>Copper</u>		<u>Aluminum</u>		<u>Steel</u>	
<u>July</u>	<u>Dec.</u>	<u>July</u>	<u>Dec.</u>	<u>July</u>	<u>Dec.</u>
75	25	375	500 +	375	375

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TABLE IV

APPEARANCE CHANGE FOR MONOETHYLENE GLYCOL
WITHOUT INHIBITORS DURING A SIX-MONTH PERIOD

<u>Copper</u>		<u>Aluminum</u>		<u>Steel</u>	
<u>July</u>	<u>Dec.</u>	<u>July</u>	<u>Dec.</u>	<u>July</u>	<u>Dec.</u>
175	175	375	500 +	175	375

Both the deionized and hard water solar fluids improved in appearance over the six-month test period as shown in Tables V and VI below.

TABLE V

APPEARANCE CHANGE FOR DEIONIZED WATER
WITHOUT INHIBITORS DURING A SIX-MONTH PERIOD

<u>Copper</u>		<u>Aluminum</u>		<u>Steel</u>	
<u>July</u>	<u>Dec.</u>	<u>July</u>	<u>Dec.</u>	<u>July</u>	<u>Dec.</u>
75	25	25	25	175	75

TABLE VI

APPEARANCE CHANGE FOR HARD WATER WITHOUT
INHIBITORS DURING A SIX-MONTH PERIOD

<u>Copper</u>		<u>Aluminum</u>		<u>Steel</u>	
<u>July</u>	<u>Dec.</u>	<u>July</u>	<u>Dec.</u>	<u>July</u>	<u>Dec.</u>
75	25	25	25	75	25

The glycerine shows no change in appearance during the test period as shown below in Table VII.

TABLE VII

APPEARANCE CHANGE FOR GLYCERINE WITHOUT
INHIBITORS DURING A SIX-MONTH PERIOD

<u>Copper</u>		<u>Aluminum</u>		<u>Steel</u>	
<u>July</u>	<u>Dec.</u>	<u>July</u>	<u>Dec.</u>	<u>July</u>	<u>Dec.</u>
175	175	175	175	175	175

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The triethylene glycol with inhibitors has darkened in appearance for all collector metals as shown in Table VIII below.

TABLE VIII
APPEARANCE CHANGE FOR TRIETHYLENE GLYCOL WITH
INHIBITOR (T-1) DURING A SIX-MONTH PERIOD

<u>Copper</u>		<u>Aluminum</u>		<u>Steel</u>	
<u>July</u>	<u>Dec.</u>	<u>July</u>	<u>Dec.</u>	<u>July</u>	<u>Dec.</u>
175	375	175	375	75	375

Composite sheets of the pH, reserve alkalinity and appearance have been included with this report. There have been no changes in reserve alkalinity except System 38, the fluid in the heat rejection system which is common to all heat exchangers and shows a decrease in reserve alkalinity from 10.6 to 3.3. This was caused by dilution by water in the heat exchangers and piping which was impossible to drain when the fluid (T-2) was added.

Since the heat rejection system operates at lower temperatures than the systems with solar collectors and is less prone to corrosion because it contains all plastic tubing, steel tanks, and copper tubing in the heat exchangers, we consider the system to have adequate freeze and corrosion protection.

The only basic changes from the initial pH data taken are in the systems using uninhibited glycols. There pH's are on the acid side and ethylene glycol has changed from 7 to 5.2. The included Table IX shows the three solar fluids without inhibitors with pH's all in the 5 and 6 range. These fluids have also become darker in appearance as compared with most other fluids which became lighter.

TABLE IX
pH OF UNINHIBITED SOLAR FLUIDS

<u>Metal</u>	<u>Original pH</u>	<u>Present pH</u>
<u>Propylene Glycol</u>		
Copper	5.2	6.4
Aluminum	5.2	5.3
Steel	5.2	5.3
<u>Ethylene Glycol</u>		
Copper	7.0	5.2
Aluminum	7.0	5.2
Steel	7.0	5.2
<u>Glycerine</u>		
Copper	5.5	5.3
Aluminum	5.5	6.0
Steel	5.5	5.7

It is early to determine if we can predict what or when a fluid will fail. But the general trends of color changes in the fluids and pH changes might indicate the following. The pH for the uninhibited glycols and glycerines are on the acid side. The color for these same fluids has become darker. Since, in an acid environment, protective oxides become increasingly more soluble, corrosion in these systems is probably occurring. The systems which are inhibited show no signs of fluid deterioration such as pH, reserve alkalinity, and color changes. The following Table X summarizes the solar heat transport fluid performance.

TABLE X
SOLAR FLUID PERFORMANCE

<u>Solar Fluids</u>	<u>Appearance</u>	<u>pH</u>	<u>Reserve Alkalinity</u>
Inhibited Glycols	Lighter	No Changes	No Changes
Deionized and Hard Water	Lighter	(<1 Change)	No Changes
Uninhibited Glycols	Darker	5-6	No Changes

CORRECTED WET CHEMISTRY DATA

Corrected data sheets have been sent to NASA as shown below.

<u>Date</u>	<u>System</u>	<u>Correct pH</u>	<u>Correct Reserve Alkalinity</u>
7/15/77	23	10.3	-
7/15/77	37	7.6	LT. 0.100
12/15/77	27	9.3	9.90
12/15/77	28	-	LT. 0.100

COLLECTOR FAILURE

System No. 9 containing a single aluminum collector with deionized water developed a leak and lost its fluid. The collector was on test for 5-1/2 months. Corrosion was expected to be the cause. But disassembly of the collector indicated that a small crack at the weld of the inlet tube to the Rollbond collector caused the loss of fluid. The inlet tube and weld section were removed from the Rollbond collector for examination. A small amount of teflon tape was discovered which probably came from the threaded coupling on the inlet tube. A brown coating was observed on the inside surface of the collector and inlet tube. The coating could not be wiped away. A sample of the coating was scraped away and X-ray analysis indicated the major constituents were aluminum, iron, and titanium with traces of chlorine and copper.

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The aluminum comes from the collector, the iron from the steel storage , the titanium is used in the masking compound when manufacturing the Rollbond aluminum collector, the chlorine is assumed to come from the soldering pastes and fluxes when assembling the plumbing system, and the copper from the copper plumbing in the system. Since the coating was not a loose film, it is suspected that the coating possibly could be a protective coating. A sample was submitted for X-ray defraction and a search was made of the defraction patterns to determine what compound or compounds, if any, are present. No positive identification could be made.

The cracked weld was rewelded and leak tested. Metal bracing plates were added at the inlet tube connection to the collector. This should eliminate future failures due to bumping the inlet tubing during inspection of the systems. The electrical heating tape on the inlet tubing to collector was found to have melted small holes in the copper tubing causing the fluid to leak. The copper tube and heating tape were replaced. The system was flushed several times with deionized water before starting the test with new deionized water.

TESTING OF NON-METALLIC SYSTEM

Delivery of the Calmac non-metallic (EPDM plastic) collector is expected after the first of the year. An ethylene glycol with inhibitors and 50% deionized water has been chosen as the solar heat transport fluid to be tested with this collector.

PROTOTYPE DESIGN REVIEW

Documentation has been sent to NASA two weeks prior to the Prototype Design Review on March 1, 1977, in accordance with the Management System (Appendix B) of this contract.

DATA ORGANIZATION

The computer program to organize the solar collector temperature and flow data to determine solar collector performance coefficients has been debugged. Other program additions are being planned to periodically take statistical averages on the performance coefficients by the panel metal and solar fluid composition.

DEVELOPMENT PLAN (APPENDIX I) CHANGE

A revised Development Plan has been submitted to NASA for approval. The basic changes are as follows:

The plan has deleted plant or pilot plant and substituted test stand and substituted systems for bank.

The additions include a computer program to organize the solar collector temperature and flow data to determine solar collector performance coefficients.

Instrumental analysis during experimental evaluation of solar collectors when deemed necessary.

Testing of a non-metallic solar collector.

Bi-monthly sampling of fluids to determine corrosion products was deleted and testing of fluid when deemed necessary was substituted. During the development of the procedure, it was learned that the test was not feasible since most corrosion products are not retained in solution.

Under panel utilization the arrangement of the system numbers was changed during installation of the collector panels to make a more meaningful arrangement.

CHANGE PROPOSAL

A Change Proposal has been submitted to NASA for approval. The extension of the contract is for three months in Article III-Term of Contract. The present term of contract is November 15, 1976, through January 15, 1979. The change term of contract would be November 15, 1976, through April 15, 1979. The reason for the change is the construction of the test stand was delayed three months due to abnormally high frequency of rainfall. It is anticipated that additional time will be required to complete the evaluation and reports of the test work.

QUARTERLY REVIEW

A quarterly review and inspection was held at the contractor's facility in Corpus Christi, Texas, on November 29 and 30, 1977. Those in attendance were the following:

John M. Caudle	NASA	Technical Manager
Bernie L. Wiesenmaier	NASA	EE01
Kenneth Lee	HCC	Corpus Christi
A. C. Ellsworth	PPG	Technical Center Manager
Charles J. Mazac	PPG	Sr. Resident Supervisor
Carl C. Clayton	PPG	Sr. Project Engineer
George L. Rich	PPG	Technical Manager
Tom S. Humphries	NASA	EH24
John Wisniewski	PPG	Program Manager
Erwin Simon	NASA	EP45
Tom Balze	HCC	Manager Technical Services
C. J. Milczarek	PPG	Analytical Supervisor

The following items were discussed after an inspection of the solar test stand and other laboratories at a meeting on November 30, 1977:

1. Combined Monthly and Quarterly Report

The writer reviewed details of the combined monthly and quarterly report for the period ending November 15, 1977.

2. Development Plan

The present development plan contains a requirement to test solar fluids to determine corrosion products, and during the development of the procedure, it was learned that the test would be of no value since corrosion products do not go into solution. It was agreed to make a change in the development plan to delete this testing and use the remaining funds for other similar tasks.

3. Air Locking Problem

Air locking has occurred in systems which have two parallel solar collector panels. Pressurizing the systems with air has relieved the problem, but it still persists. Mr. Wiesenmaier, of MSFC, suggested the possibility that the flow problem could be caused by debris in the collector. Methods of determining if air or debris are causing the problem were discussed, and no precise method could be determined. A letter was sent to Mr. Caudle, Technical Manager, explaining why we think air is causing the unbalanced temperature conditions in the parallel collector systems.

4. Disposition of Failed Collector

The single aluminum collector containing deionized water which developed a leak due to a crack weld located at the inlet tube to the Rollbond collector surface was inspected by the NASA personnel. Testing to determine a deposit of brown coating was discussed and tests have been made chemically to determine the compound of the coating.

A decision was made to repair the collector and resume tests with new deionized water.

5. Examination of Collectors at End of Test

It was agreed that a physical examination would be made of the collector passages at failure or at end of test. A procedure would be developed and NASA would be notified of this plan.

6. Testing of Non-Metallic System

Testing of a non-metallic collector was discussed. Previously the Calmac EPDM plastic collector was chosen. Dimensions for the collector has been given to Calmac and delivery is expected after the first of the year. A solar heat transport fluid was discussed and ethylene glycol was chosen at a later date.

TEST STAND ENGINEERING

PPG Engineering is supporting the solar project by monitoring test stand installation and by following up on engineering items such as drawing changes.

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SOLAR PUMP TESTS

The Grundfos pump is still running on a continuous closed loop test.

SCHEDULE

A program schedule is attached and is layed out to show the actual work performed.

EXPENDITURES

The expenditures incurred during this period are shown on the attached table.

NEXT REPORTING PERIOD

1. Sample all solar heat transport fluids every 30 days and evaluate them for deterioration and general performance by appearance, pH and reserve alkalinity analysis. Additional analysis for ash content foaming, and viscosity will be made if a solar collector panel fails or at the end of the test period whichever occurs first.
2. Develop procedures to determine when a solar collector panel fails and determine how to open collector panel internal passages for examination and determination of the corrosion rate.
3. Additions to the computer program to periodically take statistical averages of the performance coefficients by panel metal and solar fluid composition.
4. Install the Calmac non-metallic solar collector and begin testing.
5. Operate the solar test stand.



John P. Wisniewski
Project Manager

ac
Enclosures

SOLAR HEAT TRANSPORT FLUIDS
NASA CONTRACT NAS8-32255

pH

<u>System</u>	<u>Material</u>	<u>Fluid</u>	<u>Initial</u>	<u>7/15/77</u>	<u>8/15/77</u>	<u>9/15/77</u>	<u>10/15/77</u>	<u>11/15/77</u>	<u>12/15/77</u>	<u>1/15/78</u>
1	-	-								
2	Cu	P-0	5.2	6.8	8.6	6.5	6.4	6.3	6.6	6.4
3	Al	P-0	5.2	5.5	4.9	4.9	5.0	5.2	5.0	5.3
4	Stl	P-0	5.2	5.9	5.1	4.9	5.1	5.1	5.0	5.3
5	Cu	M-0	7.0	5.9	5.4	5.1	5.1	5.2	5.1	5.2
6	Al	M-0	7.0	6.3	5.2	5.4	5.2	5.3	5.2	5.2
7	Stl	M-0	7.0	4.8	4.8	4.9	5.3	5.2	5.0	5.2
8	Cu	D-W	7.1	8.0	6.8	6.9	7.0	7.1	7.4	6.9
9	Al	D-W	7.1	8.0	7.6	7.7	7.2	7.1		*7.1
10	Stl	D-W	7.1	5.6	6.3	6.1	5.9	5.9	5.9	6.1
11	Cu	G-0	5.5	6.2	5.3	5.1	5.1	5.6	5.1	5.3
12	Cu	T-1	9.6	9.5	9.8	9.9	10.0	10.1	10.0	10.1
13	Cu	P-2	9.8	9.8	9.9	9.8	10.0	10.0	9.9	9.9
14	Cu	P-1	9.8	9.6	9.6	9.5	9.6	9.6	9.6	9.5
15	Cu	M-4	9.4	9.5	9.4	9.3	9.4	9.4	9.3	9.3
16	Cu	M-3	9.5	9.4	9.4	9.3	9.4	9.4	9.3	9.3
17	Cu	M-2	8.8	8.8	8.8	8.8	8.9	8.8	8.8	8.8
18	Cu	M-1	9.4	9.3	9.2	9.2	9.3	9.2	9.2	9.2
19	Cu	H-W	8.2	8.0	8.4	8.1	8.2	8.2	8.4	8.5
20	Al	G-0	5.5	6.1	6.2	7.2	5.3	5.4	6.0	6.0
21	Al	T-1	9.6	10.1	10.2	10.3	10.5	10.2	10.2	10.2
22	Al	P-2	9.8	10.2	10.3	10.3	10.4	10.3	10.3	10.3
23	Al	P-1	9.8	10.3	10.5	10.6	10.6	10.6	10.5	10.7
24	Al	M-4	9.4	9.4	9.4	9.5	9.5	9.4	9.4	9.4
25	Al	M-3	9.5	9.5	9.4	9.5	9.5	9.4	9.4	9.7
26	Al	M-2	8.8	9.1	9.1	9.3	9.3	9.2	9.2	9.3
27	Al	M-1	9.4	9.3	9.3	9.3	9.3	9.2	9.3	9.3
28	Al	H-W	8.2	7.8	8.5	8.0	8.5	8.4	9.2	8.4
29	Stl	G-0	5.5	5.9	5.2	6.6	6.5	5.3	5.2	5.7
30	Stl	T-1	9.6	9.5	9.8	9.9	10.2	10.2	10.3	10.3
31	Stl	P-2	9.8	9.8	9.8	9.9	9.9	9.9	9.9	10.0
32	Stl	P-1	9.8	9.6	9.6	9.6	9.6	9.6	9.6	9.6
33	Stl	M-4	9.4	9.3	9.3	9.3	9.3	9.3	9.3	9.3
34	Stl	M-3	9.5	9.2	9.3	9.2	9.2	9.2	9.2	9.2
35	Stl	M-2	8.8	9.8	8.8	8.9	8.8	8.9	8.8	8.9
36	Stl	M-1	9.4	9.3	9.2	9.2	9.2	9.3	9.2	9.2
37	Stl	H-W	8.2	7.6	8.0	8.1	8.2	8.3	8.4	8.1
38	Mix	T-2	8.7	-	8.6	8.5	8.7	8.6	8.6	8.6

*New fluid installed

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SOLAR HEAT TRANSPORT FLUIDSNASA CONTRACT NAS8-32255RESERVE ALKALINITY

<u>System</u>	<u>Material</u>	<u>Fluid</u>	<u>Initial</u>	<u>7/15/77</u>	<u>8/15/77</u>	<u>9/15/77</u>	<u>10/15/77</u>	<u>11/15/77</u>	<u>12/15/77</u>	<u>1/15/78</u>
1										
2	Cu	P-0								
3	Al	P-0								
4	Stl	P-0								
5	Cu	M-0								
6	Al	M-0								
7	Stl	M-0								
8	Cu	D-W								
9	Al	D-W								
10	Stl	D-W								
11	Cu	G-0								
12	Cu	T-1	6.10	6.10	6.10	5.90	6.05	5.90	6.00	6.00
13	Cu	P-2	6.25	6.30	6.20	6.10	6.15	6.10	6.20	6.10
14	Cu	P-1	6.00	5.95	5.90	5.80	5.90	5.80	5.90	6.00
15	Cu	M-4	6.65	6.50	6.50	6.50	6.50	6.40	6.50	6.50
16	Cu	M-3	6.65	6.45	6.50	6.50	6.50	6.40	6.50	6.50
17	Cu	M-2	11.45	11.30	11.40	11.30	11.35	11.20	11.40	11.30
18	Cu	M-1	9.90	9.50	9.10	9.10	9.20	9.00	9.10	9.10
19	Cu	H-W				0.120				
20	Al	G-0								
21	Al	T-1	6.10	6.00	6.00	6.00	6.00	5.90	6.00	6.00
22	Al	P-2	6.25	6.20	6.25	6.20	6.23	6.20	6.40	6.30
23	Al	P-1	6.00	5.90	5.95	5.90	5.90	5.90	5.95	5.90
24	Al	M-4	6.55	6.60	6.65	6.60	6.70	6.55	6.70	6.60
25	Al	M-3	6.55	6.60	6.60	6.70	6.65	6.50	6.60	6.60
26	Al	M-2	11.45	11.50	11.50	11.40	11.50	11.30	11.40	11.50
27	Al	M-1	9.90	9.90	10.00	9.95	9.90	9.80	9.90	9.90
28	Al	H-W								
29	Stl	G-0								
30	Stl	T-1	6.10	6.10	6.05	6.10	6.05	5.90	6.10	6.00
31	Stl	P-2	6.25	6.20	6.21	6.30	6.15	6.10	6.30	6.20
32	Stl	P-1	6.00	5.90	5.90	6.10	5.90	6.00	6.00	5.90
33	Stl	M-4	6.65	6.60	6.63	6.70	6.65	6.50	6.60	6.60
34	Stl	M-3	6.65	6.60	6.58	6.60	6.60	6.50	6.60	6.60
35	Stl	M-2	11.45	11.40	11.24	11.50	11.40	11.25	11.40	11.40
36	Stl	M-1	9.90	9.90	9.840	9.80	9.85	9.70	9.90	9.90
37	Stl	H-W								
38	Mix	T-2	10.6	-	3.23	3.30	3.45	3.10	3.20	3.30

NOTE: All blank spaces are <0.100

ORIGINAL PAGE IS
OF POOR QUALITY

SOLAR HEAT TRANSPORT FLUID

VISUAL APPEARANCE TEST
NASA CONTRACT NO. 8-32255

<u>System</u>	<u>Fluid</u>	<u>Material</u>	<u>7/15/77</u>	<u>8/15/77</u>	<u>9/15/77</u>	<u>10/15/77</u>	<u>11/15/77</u>	<u>12/15/77</u>
1								
2	P-0	Cu	50-100	50-100	50-100	100-250	0- 50	0- 50
3	P-0	Al	250-500	250-500	100-250	500 +	250-500	500 +
4	P-0	Steel	250-500	250-500	250-500	250-500	250-500	250-500
5	M-0	Cu	100-250	100-250	100-250	100-250	100-250	100-250
6	M-0	Al	250-500	100-250	250-500	250-500	500 +	500 +
7	M-0	Steel	100-250	250-500	250-500	250-500	250-500	250-500
8	DW	Cu	50-100	100-250	50-100	0- 50	0- 50	0- 50
9	DW	Al	0- 50	50-100	0- 50	50-100	0- 50	-
10	DW	Steel	100-250	100-250	100-250	50-100	50-100	50-100
11	G-0	Cu	100-250	100-250	100-250	100-250	100-250	100-250
12	T-1	Cu	100-250	100-250	100-250	100-250	250-500	250-500
13	P-2	Cu	50-100	50-100	0- 50	0- 50	0- 50	0- 50
14	P-1	Cu	100-250	50-100	0- 50	0- 50	0- 50	0- 50
15	M-4	Cu	50-100	50-100	50-100	50-100	0- 50	0- 50
16	M-3	Cu	50-100	50-100	50-100	0- 50	50-100	0- 50
17	M-2	Cu	50-100	50-100	50-100	50-100	0- 50	0- 50
18	M-1	Cu	50-100	50-100	50-100	50-100	0- 50	0- 50
19	HW	Cu	50-100	50-100	50-100	50-100	0- 50	0- 50
20	G-0	Al	100-250	100-250	100-250	100-250	100-250	100-250
21	T-1	Al	100-250	100-250	100-250	100-250	250-500	250-500
22	P-2	Al	50-100	50-100	50-100	50-100	0- 50	0- 50
23	P-1	Al	0-50	0- 50	50-100	0- 50	0- 50	0- 50
24	M-4	Al	50-100	50-100	50-100	50-100	50-100	50-100
25	M-3	Al	50-100	50-100	50-100	0- 50	50-100	0- 50
26	M-2	Al	50-100	50-100	50-100	0- 50	0- 50	0- 50
27	M-1	Al	50-100	50-100	50-100	0- 50	0- 50	0- 50
28	HW	Al	0- 50	50-100	0- 50	50-100	0- 50	0- 50
29	G-0	Steel	100-250	100-250	100-250	100-250	100-250	100-250
30	T-1	Steel	50-100	100-250	100-250	100-250	250-500	250-500
31	P-2	Steel	50-100	50-100	50-100	50-100	50-100	50-100
32	P-1	Steel	50-100	50-100	50-100	50-100	50-100	50-100
33	M-4	Steel	50-100	50-100	50-100	100-250	50-100	50-100
34	M-3	Steel	100-250	100-250	100-250	50-100	100-250	50-100
35	M-2	Steel	100-250	100-250	100-250	100-250	250-500	100-250
36	M-1	Steel	100-250	100-250	50-100	50-100	50-100	100-250
37	HW	Steel	50-100	0- 50	50-100	0- 50	0- 50	0- 50
38	T-2	Mix	-	100-250	100-250	100-250	100-250	100-250

SOLAR HEAT TRANSPORT FLUID (Page 2)VISUAL APPEARANCE TESTNASA CONTRACT NO. 8-32255

<u>System</u>	<u>Fluid</u>	<u>Material</u>	<u>1/15/78</u>
1			
2	P-0	Cu	100-250
3	P-0	Al	500 +
4	P-0	Steel	250-500
5	M-0	Cu	100-250
6	M-0	Al	500 +
7	M-0	Steel	250-500
8	DW	Cu	0-050
9	DW	Al	50-100
10	DW	Steel	0-050
11	G-0	Cu	100-250
12	T-1	Cu	500 +
13	P-2	Cu	0-050
14	P-1	Cu	0-050
15	M-4	Cu	0-050
16	M-3	Cu	0-050
17	M-2	Cu	0-050
18	M-1	Cu	0-050
19	HW	Cu	0-050
20	G-0	Al	100-250
21	T-1	Al	500 +
22	P-2	Al	0-050
23	P-1	Al	0-050
24	M-4	Al	0-050
25	M-3	Al	0-050
26	M-2	Al	0-050
27	M-1	Al	0-050
28	HW	Al	0-050
29	G-0	Steel	100-250
30	T-1	Steel	500 +
31	P-2	Steel	50-100
32	P-1	Steel	50-100
33	M-4	Steel	50-100
34	M-3	Steel	100-250
35	M-2	Steel	100-250
36	M-1	Steel	100-250
37	HW	Steel	0-050
38	T-2	Mix	100-250

SOLAR HEAT TRANSPORT FLUID - PROGRAM SCHEDULE

1976

1977

1978

Nov Dec Jan Feb Mar Apr May June July Aug Sept Oct Nov Dec Jan Feb Mar Apr May June July Aug Sept Oct Nov Dec Jan

TEST STAND-Construction

PAVING

BASIC STRUCTURE

PLUMBING

ELECTRICAL

INSTRUMENTATION & INSTALLING TEST FLUIDS & SYSTEMS CHECKOUTS

MAINTENANCE

TEST STAND-Engineering

STRUCTURE

SITE LOCATION

PLUMBING LAYOUT

ELECTRICAL LAYOUT

INSTRUMENTATION

PROJECT MANAGEMENT

CONTRACT SUPERVISION

DEVELOPMENT/QUALIFICATION TESTS

GLASSWARE CORROSION TESTS

CORROSION, SIMULATED SERVICE

SOLAR HEAT TRANSPORT FLUID WET CHEMISTRY TESTS

SOLAR HEAT TRANSPORT FLUID INSTRUMENTAL TESTS

SURFACE INSPECTION OF COLLECTOR PANELS

COLLECTOR CORROSION EVALUATION

ACCEPTANCE TEST

DELIVERY

FINAL DELIVERABLE HEAT TRANSPORT FLUIDS

ORIGINAL PAGE IS OF POOR QUALITY

LEGEND ☆ U. S. GOVERNMENT PRINTING OFFICE 1978-740-193/342 REGION NO. 4

PROPOSED--BEFORE WEATHER DELAYS

SCHEDULED

COMPLETED

△ MONTHLY STATUS REPORT

□ QUARTERLY REVIEW

○ PRELIMINARY DESIGN REVIEW

○ PROTOTYPE DESIGN REVIEW

Date

Submitted

By

2/15/78

Sh. W. W. W.